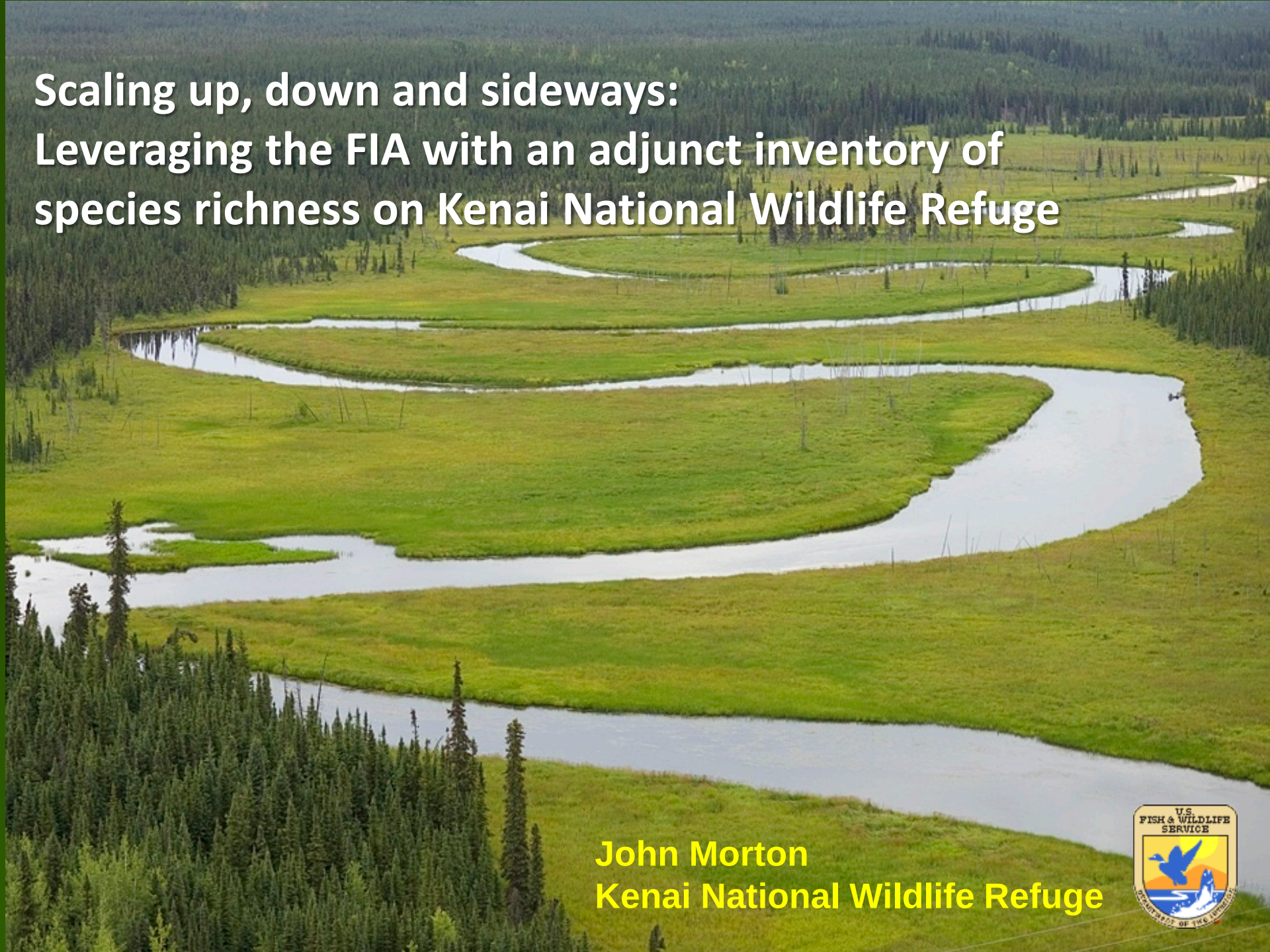
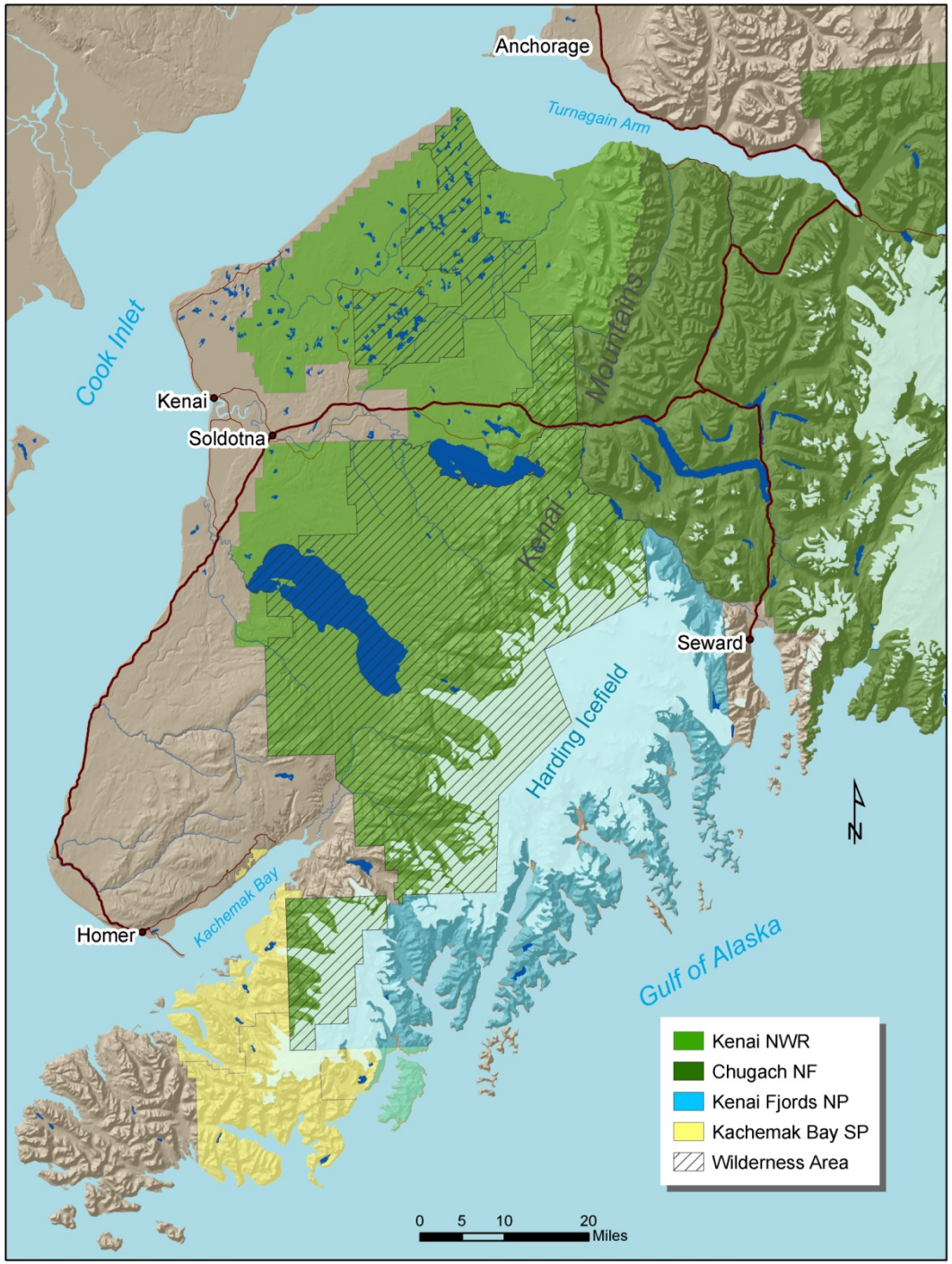
Scaling up, down and sideways: Leveraging the FIA with an adjunct inventory of species richness on Kenai National Wildlife Refuge



John Morton
Kenai National Wildlife Refuge


Anchorage
Turnagain Arm
Cook Inlet
Kenai
Soldotna
Kenai
Mountains
Seward
Harding Icefield
Homer
Kachemak Bay
Gulf of Alaska
N
Kenai NWR
Chugach NF
Kenai Fjords NP
Kachemak Bay SP
Wilderness Area
0 5 10 20
Miles

ALASKA

Headquarters
Kenai
National
Wildlife
Refuge

REFUGE PURPOSES

1964 Wilderness Act

1997 NWRS Improvement Act

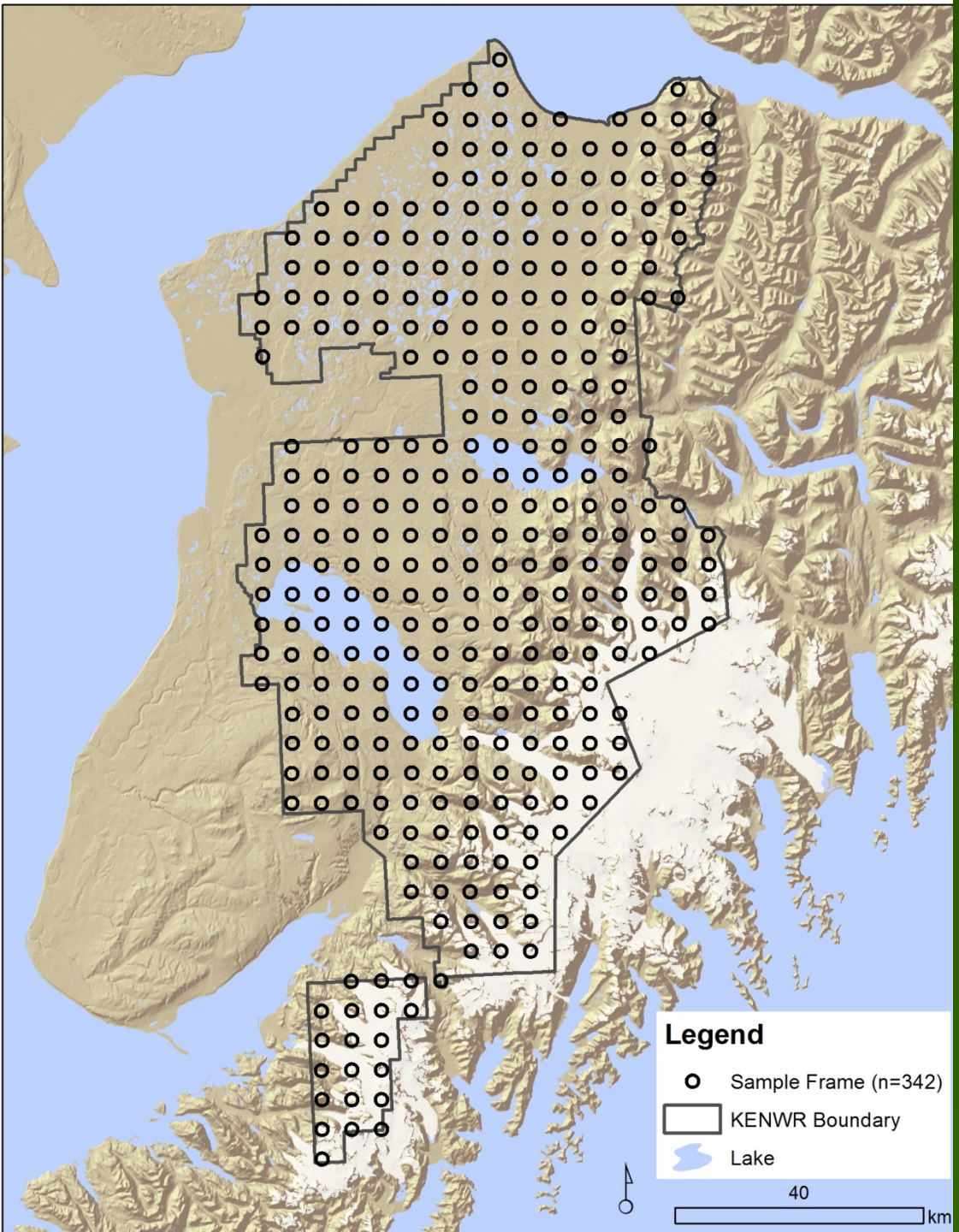
1980 ANILCA

fish and wildlife = any member of the animal kingdom including without limitation any mammal, fish, bird, amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate…

eir

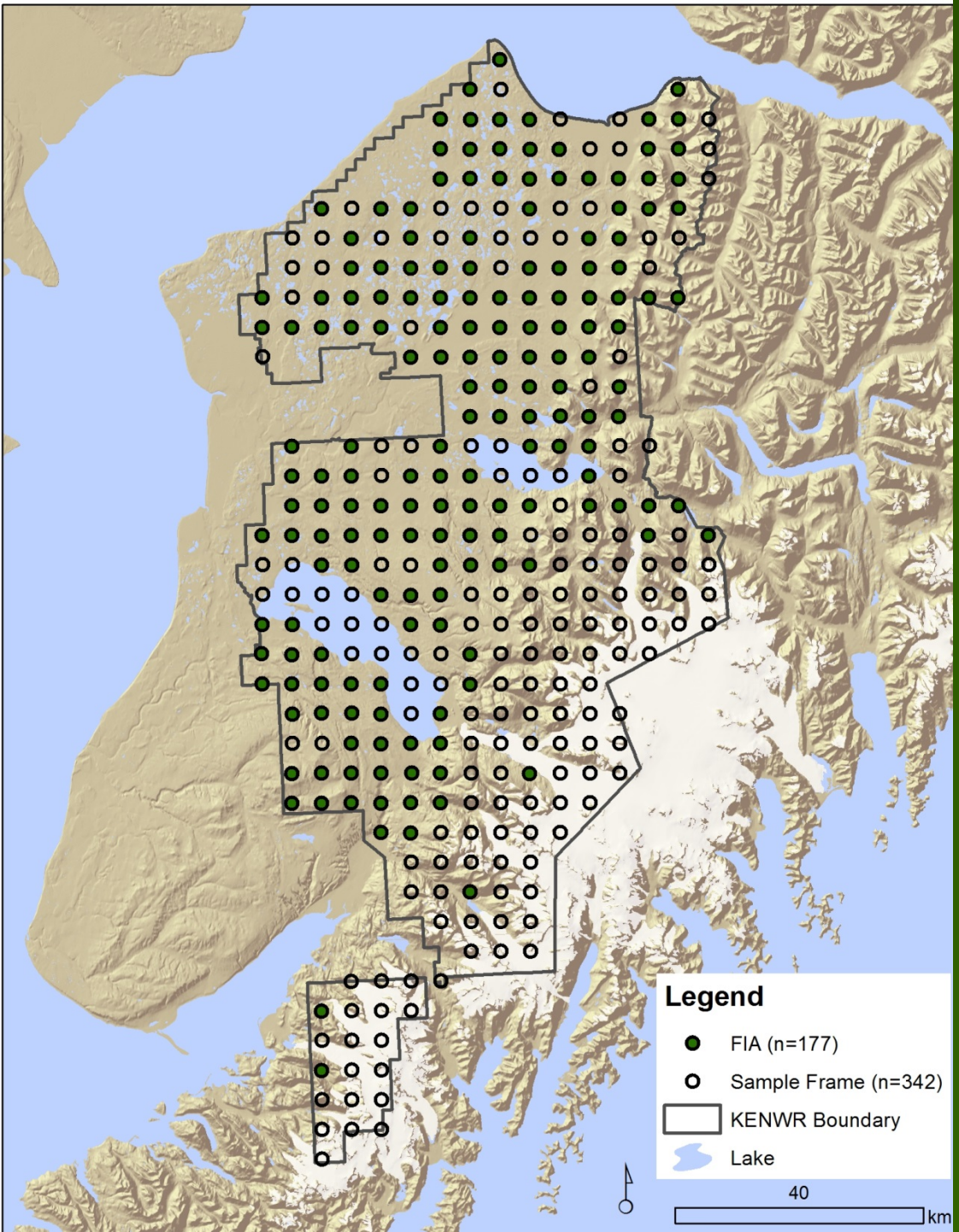
Long Term Ecological Monitoring Program

- Determine the occurrence and distribution of selected terrestrial flora & fauna (inventory)
- Assess trends in occurrence and distribution of selected terrestrial flora & fauna (monitoring)
- Develop explanatory statistical models to assess effects of physical, biological, and anthropogenic factors on distributions



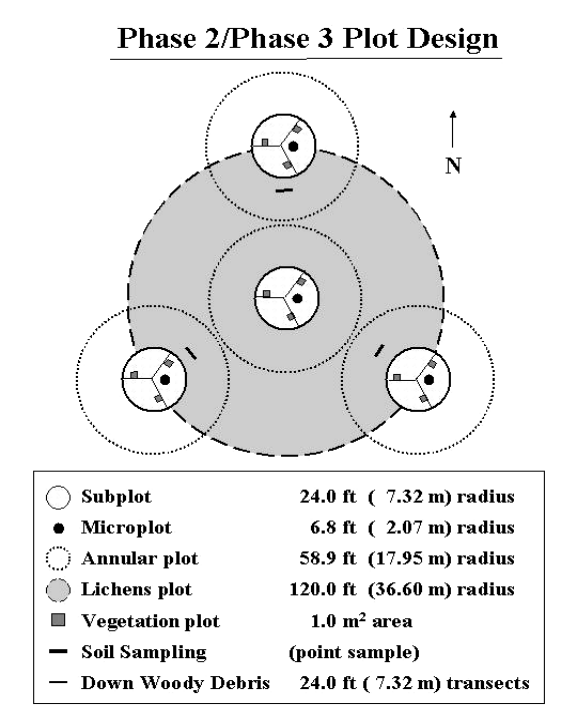
Although regionally scaled, data from LTEMP are representative of KENWR…

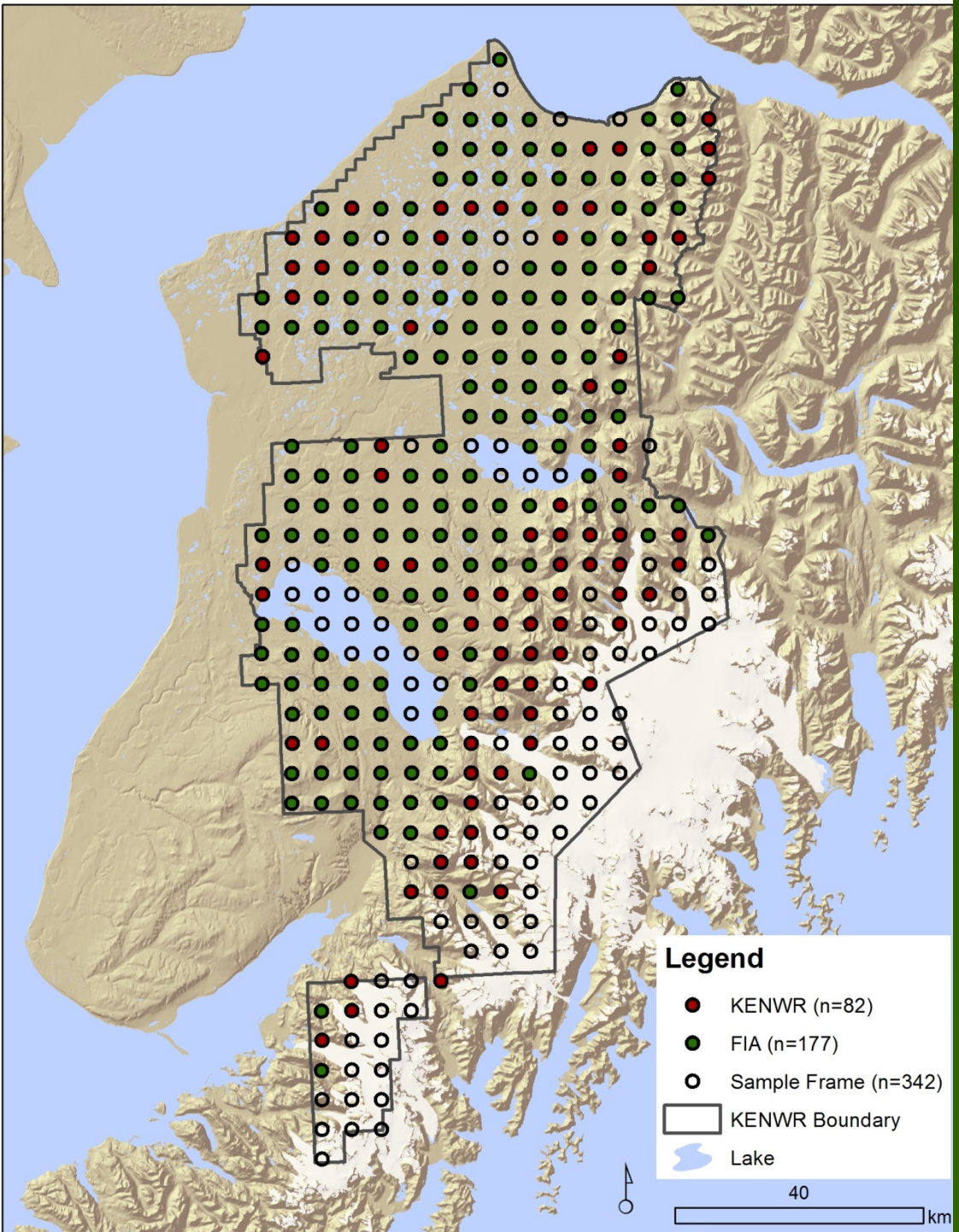
HABITAT	PLOTS (%)	ACRES (%)
Forest	161 (47)	945,896 (48)
conifer	105 (31)	550,996 (28)
deciduous	12 (4)	72,805 (4)
mixed	44 (13)	322,095 (16)
Shrub/grass	26 (7)	141,819 (7)
Barren/sparsely vegetated	59 (17)	329,293 (17)
Wetlands	20 (6)	122,292 (6)
Snow/ice	51 (15)	289,974 (15)
Water	25 (7)	159,242 (8)
Σ	342 (100)	1,988,516 (101)



1999-2002

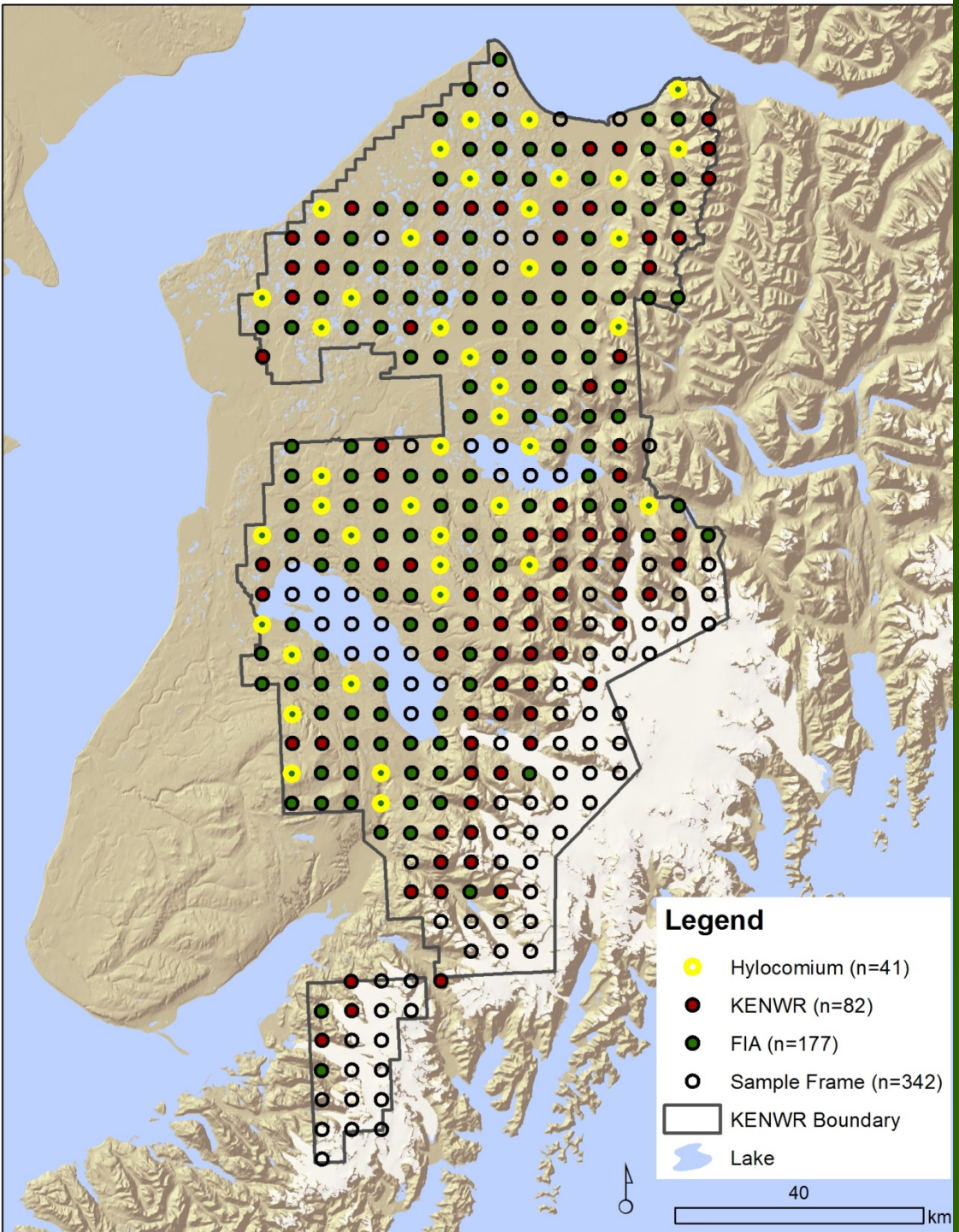
177 FIA plots (with HV) in forests at 5-km intervals





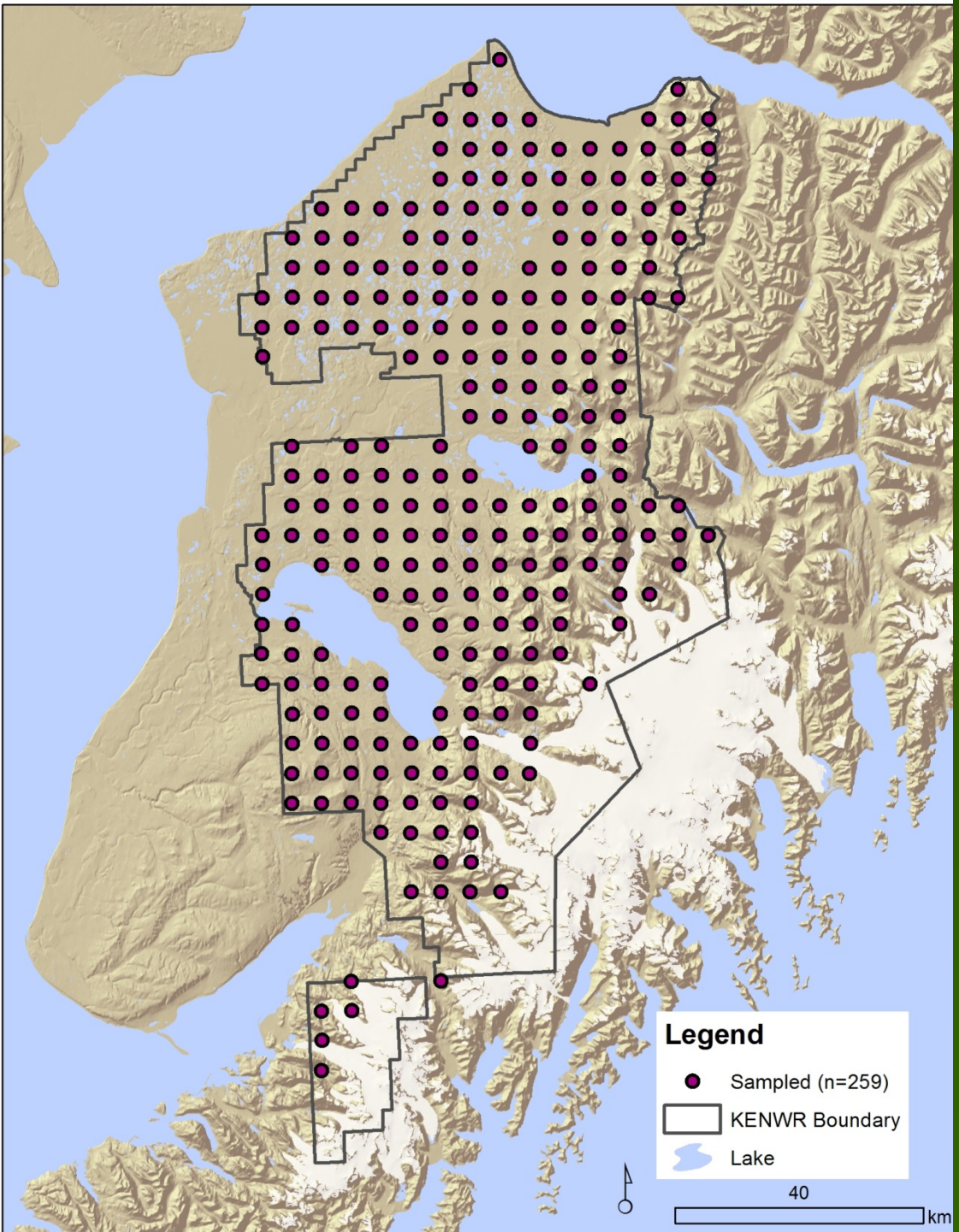
2004/2006

Another 82 plots in nonforested habitats



2008

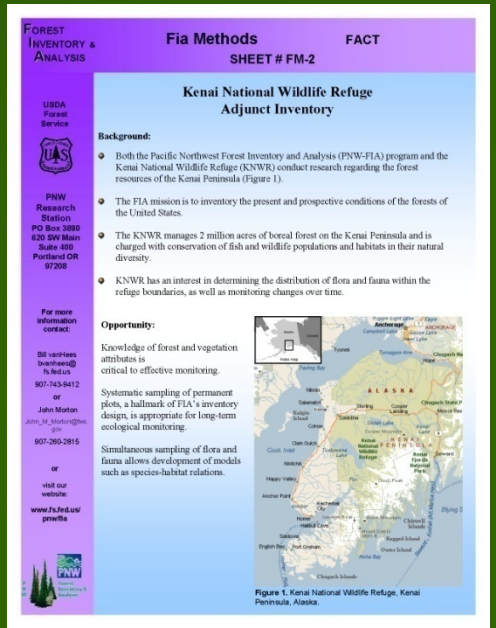
Resampled 50 FIA plots for mosses and lichens



LTEMP

342 permanent plots systematically arrayed at 5-km intervals, of which 259 plots were sampled cooperatively with FIA

2004 MOU designated LTEMP as FIA adjunct inventory



FOREST INVENTORY & ANALYSIS

Fia Methods FACT

SHEET # FM-2

USDA Forest Service

PNW Research Station
PO Box 3890
620 SW Main
Suite 400
Portland OR
97208

For more information contact:

Bill vanHees
bvanhees@fs.fed.us
907-743-9412
or
John Morton
John_M_Morton@fws.gov
907-260-2815

or
visit our website:
www.fs.fed.us/pnw/fia

Kenai National Wildlife Refuge Adjunct Inventory

Background:

- Both the Pacific Northwest Forest Inventory and Analysis (PNW-FIA) program and the Kenai National Wildlife Refuge (KNWR) conduct research regarding the forest resources of the Kenai Peninsula (Figure 1).
- The FIA mission is to inventory the present and prospective conditions of the forests of the United States.
- The KNWR manages 2 million acres of boreal forest on the Kenai Peninsula and is charged with conservation of fish and wildlife populations and habitats in their natural diversity.
- KNWR has an interest in determining the distribution of flora and fauna within the refuge boundaries, as well as monitoring changes over time.

Opportunity:

Knowledge of forest and vegetation attributes is critical to effective monitoring.

Systematic sampling of permanent plots, a hallmark of FIA's inventory design, is appropriate for long-term ecological monitoring.

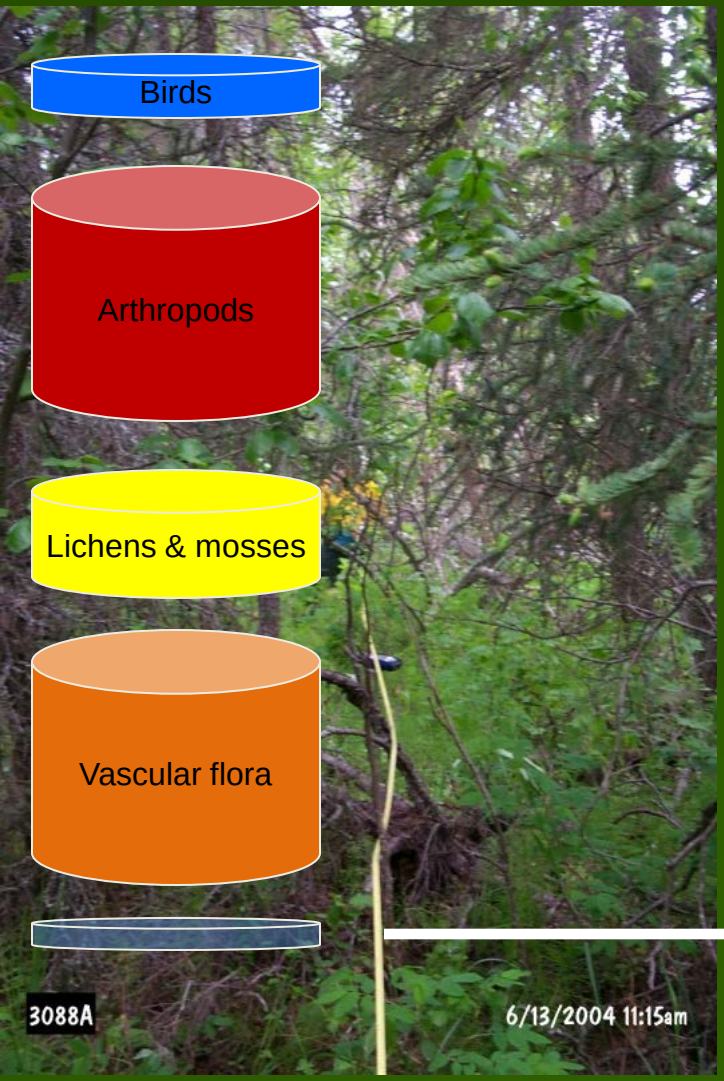
Simultaneous sampling of flora and fauna allows development of models such as species-habitat relations.

Figure 1. Kenai National Wildlife Refuge, Kenai Peninsula, Alaska.

Data collected in 2004, 2006 & 2008

- Vascular (including exotics) & nonvascular flora on nonforested points (modified line intercept)
- Breeding bird densities (VCP)
- Insect relative abundance (sweep nets)
- Heavy metal uptake (Hylocomium)
- Rose galls as disturbance index
- Ambient noise recordings

LTEMP site 3088

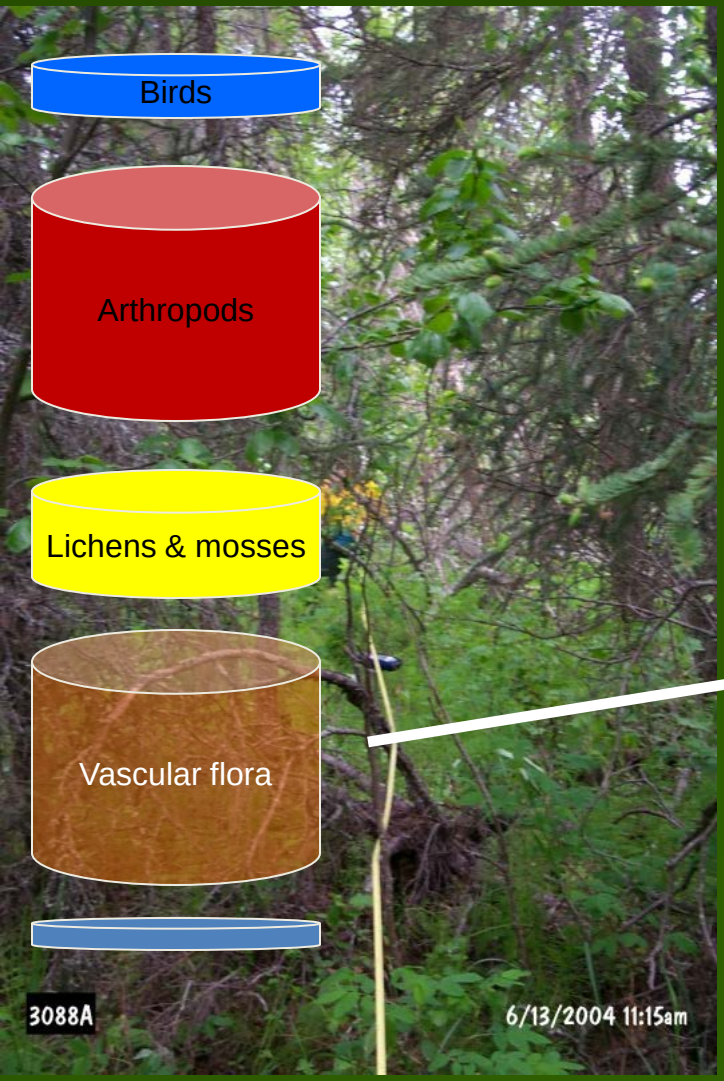


100 m^2

GIS derived data

black spruce (IA2F), 40 years old
elevation = 20 m
patch size = 57 ha
nearest stream = 105 m
nearest road = 2725 m
nearest border = 1119 m
Leq = 46.4 dBa
Rose galls = 0
mean annual temp = 3.2°C
mean annual precip= 433 mm

LTEMP site 3088

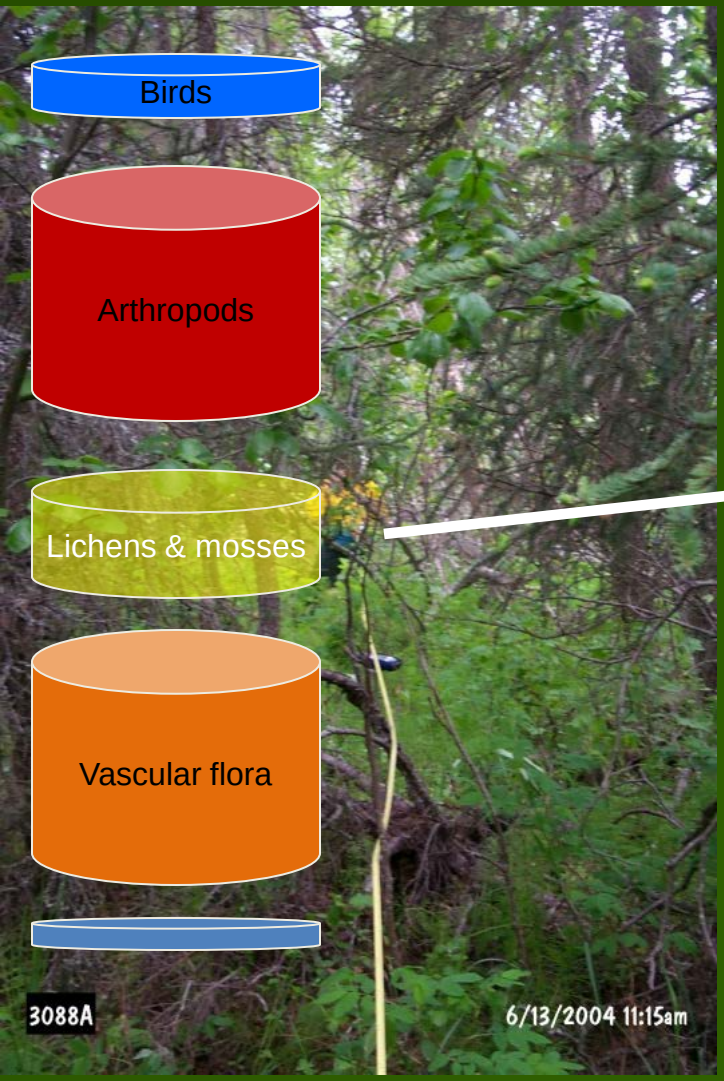


100 m^2

26 species of vascular plants

Alanus incana
Athyruium filiz-femina
Betula nana
Calamagrostis candadensis
Chamerion angustifolium
Cornus canadensis
Dryopteris expansa
Empetrum nigrum
Equisetum sylvaticum
Equisetum arvense
Gymnocarpium dryopteris
Linnaea borealis
Mertensia paniculata
Picea mariana
Pyrola minor
Ribes glandulosum
Ribes hudsonianum
Ribes triste
Rosa acicularis
Rubus arcticus
Saliz pulchra
Sanguisorba candadensis
Spiraea stevenii
Trientalis europaea
Vaccinium uliginosum
Vaccinium vitis-idaea

LTEMP site 3088

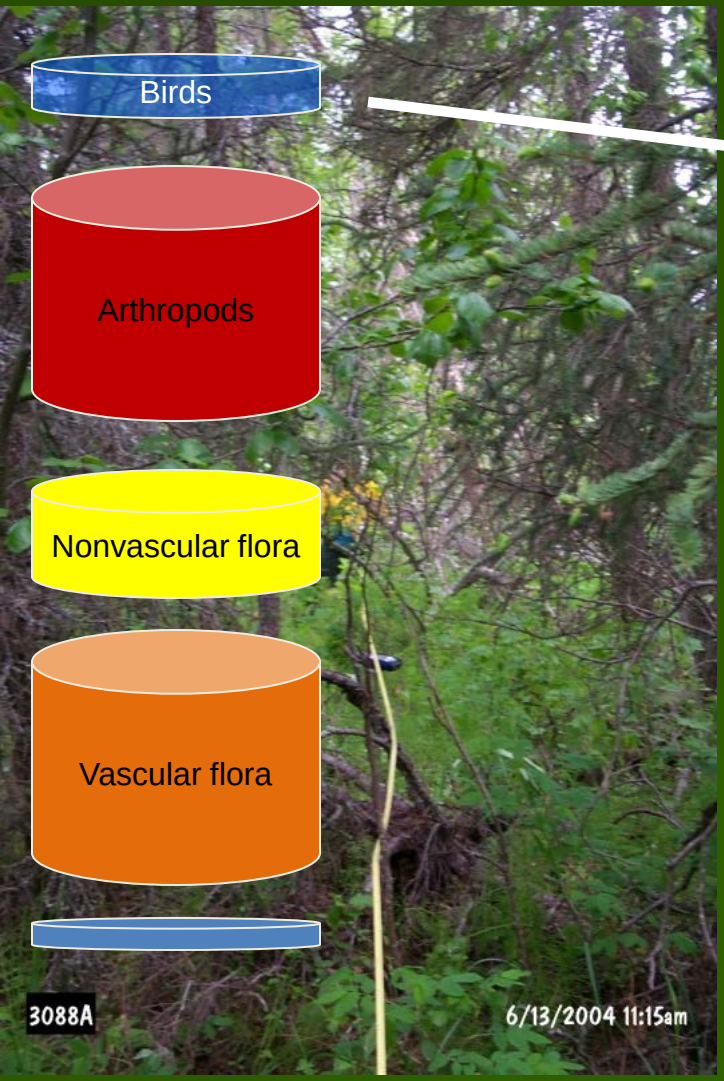


9 lichen & moss species

Ptilidium ciliare
Drepanocladus uncinnatus
Stereocaulon alpinum
Aulacomnium palustre
Cladonia umbricola
Parmelia sulcata
Pleurozium schreberi
Rhizomnium nudum
Brachythecium sp.

100 m^2

LTEMP site 3088

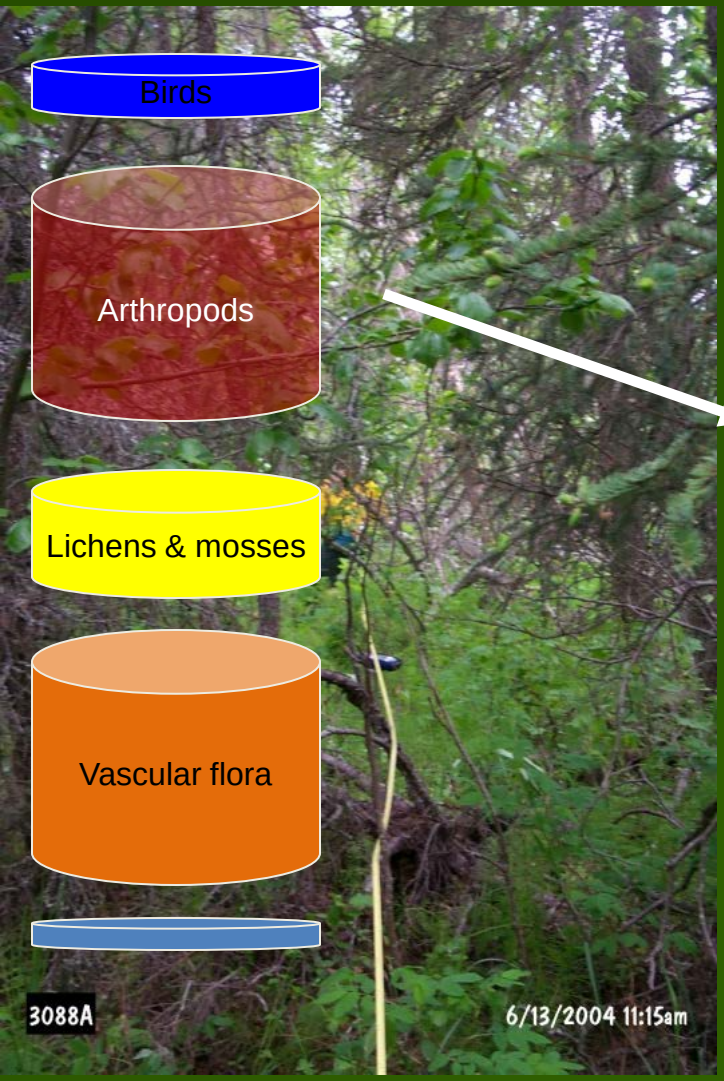


7 bird species

- Alder flycatcher
- Cliff swallow
- Orange crowned warbler
- Ruby-crowned kinglet
- Swainson's thrush
- White-winged crossbill
- Wilson's snipe

100 m^2

LTEMP site 3088

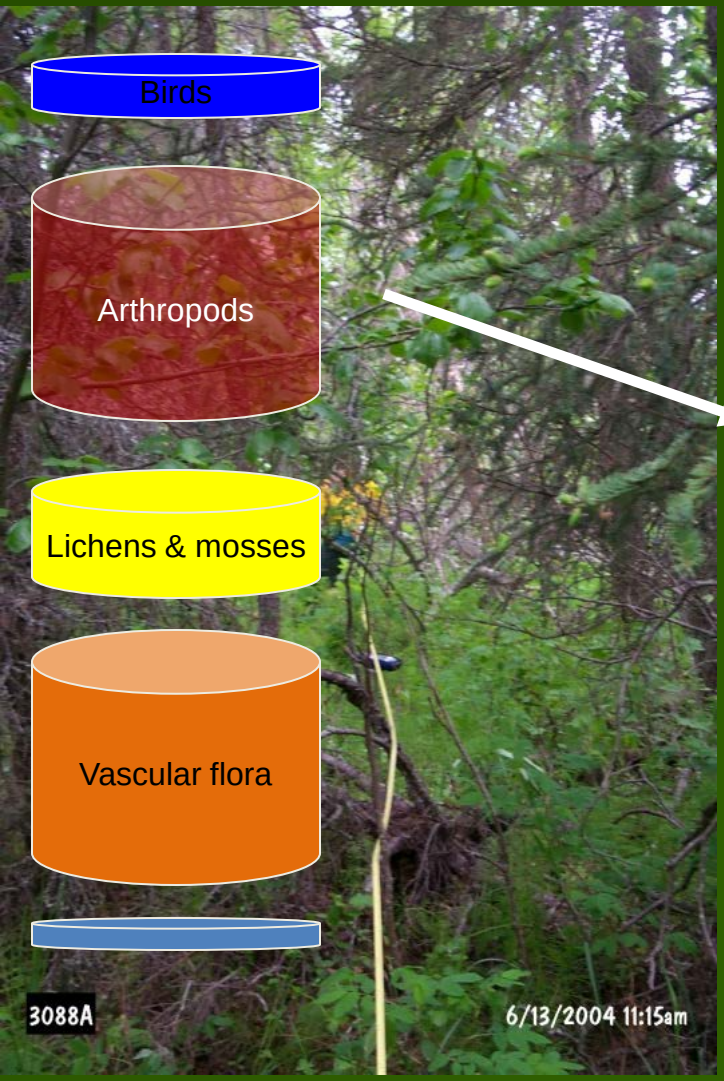


100 m^2

Aphididae
Aphidius
Araneae
Balclutha manitou
Braconidae
Craspedolepta
Culicidae
Diptera
Dismodicus modicus
Ephedrus lacertosus
Euthyneura nr. albipennis
Fannia postica
Fannia serena
Fannia spathiophora
Fannia subpellucens
Hemerobiidae
Ichneumonidae
Javesella pellucida
Lepidoptera
Melanostoma mellinum
Mycetophilidae
Phaenoglyphis kenaii
Podabrini
Sapromyza TAW1 BOLD:AAG6931
Simuliidae
Sminthurus

26 arthropod taxa and counting

LTEMP site 3088



100 m^2

Aphididae
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Araneae
Balclutha manitou
Braconidae
Craspedolepta
Culicidae
Diptera
Dismodicus modicus
Ephedrus lacertosus
Euthyneura nr. albipennis
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Fannia serena
Fannia spathiophora
Fannia subpellucens
Hemerobiidae
Ichneumonidae
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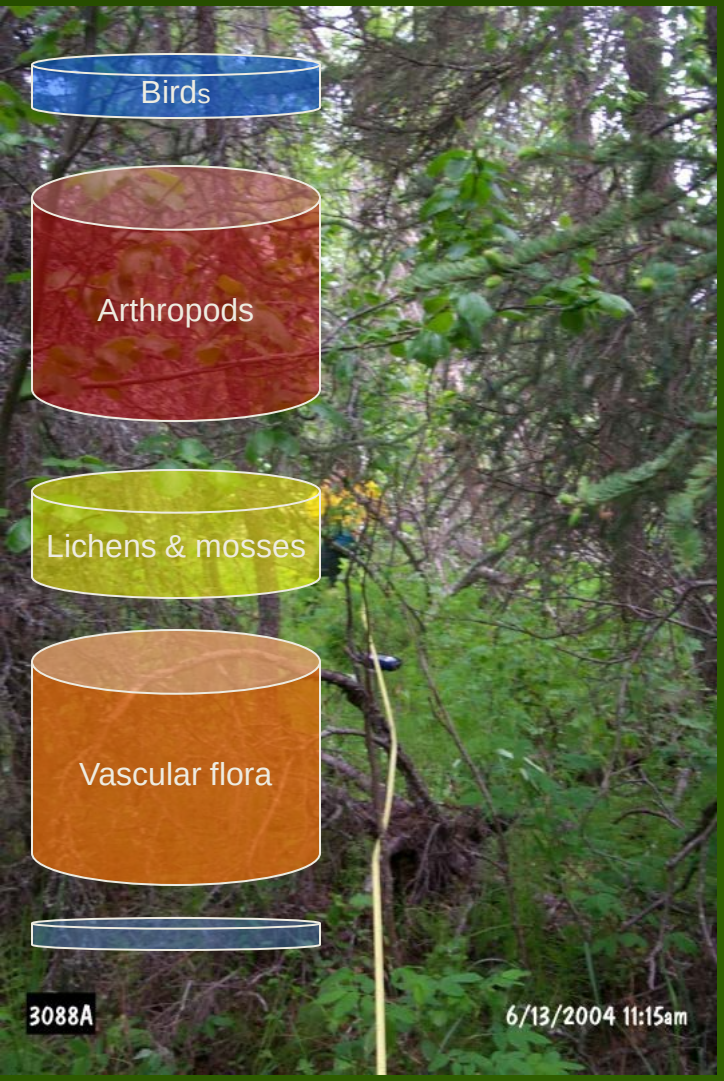
26 arthropod taxa and counting

LTEMP site 3088



100 m^2

Alder flycatcher
Cliff swallow
Orange crowned warbler
Ruby-crowned kinglet
Swainson's thrush
White-winged crossbill
Wilson's snipe

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Equisetum arvense
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Linnaea borealis
Mertensia paniculata
Picea mariana
Pyrola minor
Ribes glandulosum
Ribes hudsonianum
Ribes triste
Rosa acicularis
Rubus arcticus
Saliz pulchra
Sanguisorba candadensis
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Vaccinium uliginosum
Vaccinium vitis-idaea

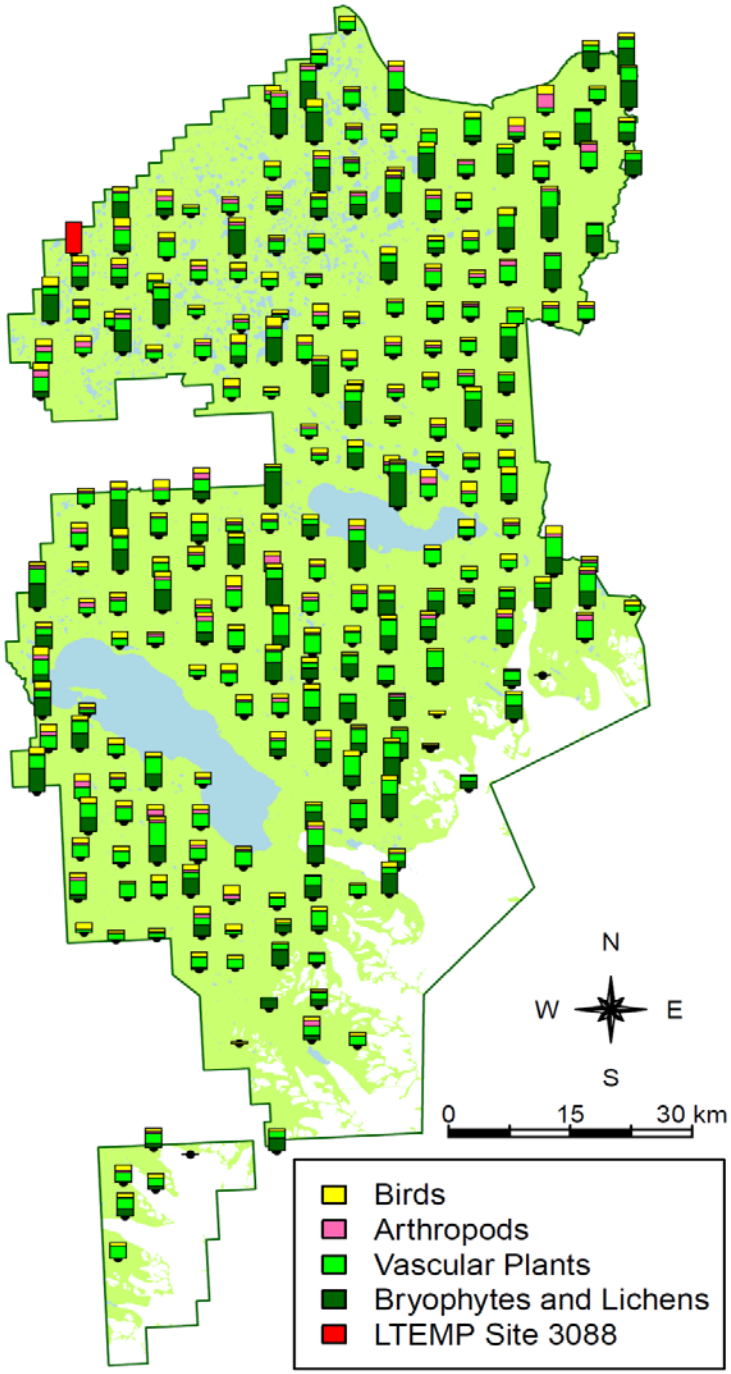
black spruce (IA2F), 40 years old
elevation = 20 m
patch size = 57 ha
nearest stream = 105 m
nearest road = 2725 m
nearest border = 1119 m
Leq = 46.4 dBa
Rose galls = 0
mean annual temp = 3.2°C
mean annual precip= 433 mm

1,092 species to date!

80 birds
228 arthropods
4 snails
307 vascular plants
298 lichens
123 mosses
22 ferns and allies
30 liverworts

species assemblages
spatial distribution
temporal change
explanatory models

1 – 87 species per 100m^2 plot with mean = 37



- 2 insect species new to science!!
- 1 insect family (Achilidae) new to Alaska
- 14 insect species new to Alaska
- 2 new sedges (*Carex* spp.) for KENWR
- range expansion for Hammond's flycatcher

SYSTEMATICS

First Records, New Species, and a Key of the Charipinae (Hymenoptera: Cynipoidea: Figitidae) From the Nearctic Region

MAR FERRER-SUAY,[1,2] J. SELFA,[3] AND J. PUJADE-VILLAR[1]

Ann. Entomol. Soc. Am. 107(1): 50–73 (2014); DOI: http://dx.doi.org/10.1603/AN13077

ABSTRACT The Charipinae material deposited in the United States National Museum of Natural History (Smithsonian Institution) and some specimens deposited in the Canadian National Collection of Insects from the Nearctic region have been revised. In all, 337 specimens have been included in this study and 27 species have been determined. Sixteen species are reported for the first time from the Nearctic region: *Alloxysta arcuata* (Kieffer, 1902), *Alloxysta brevis* (Thomson, 1862), *Alloxysta castanea* (Hartig, 1841), *Alloxysta citripes* (Thomson, 1862), *Alloxysta darci* (Girault, 1933), *Alloxysta fracticornis* (Thomson, 1862), *Alloxysta halterata* (Thomson, 1862), *Alloxysta macrophadna* (Hartig, 1841), *Alloxysta mullensis* (Cameron, 1883), *Alloxysta pilipennis* (Hartig, 1840), *Alloxysta postica* (Hartig, 1841), *Alloxysta proxima* (Belizin, 1962), *Alloxysta ramulifera* (Thomson, 1862), *Phaenoglyphis heterocera* (Hartig, 1841), *Phaenoglyphis salicis* (Cameron, 1883), and *Phaenoglyphis stricta* (Thomson, 1877). Seven new species are described: *Alloxysta buffingtoni* Ferrer-Suay & Pujade-Villar n. sp., *Alloxysta huberi* Ferrer-Suay & Pujade-Villar n. sp., *Alloxysta neartica* Ferrer-Suay & Pujade-Villar n. sp., *Alloxysta texana* Ferrer-Suay & Pujade-Villar n. sp., *Alloxysta vicenti* Ferrer-Suay n. sp., *Phaenoglyphis jeffersoni* Ferrer-Suay & Pujade-Villar n. sp., and *Phaenoglyphis kenaii* Ferrer-Suay & Pujade-Villar n. sp. Diagnoses are given for the species newly recorded in this region and their main diagnostic features are present in different plates. New species are completely described and illustrated. A key to identify the Charipinae present in the Nearctic region is also given.

KEY WORDS Figitidae, Charipinae, *Alloxysta*, *Phaenoglyphis*, Nearctic region

Members of the subfamily Charipinae (Hymenoptera: Cynipoidea: Figitidae) are widely distributed around ... characterized as being a ... The

(Kieffer 1907), *Alloxysta bicolor* (Baker, 1896), *Alloxysta commensuratus* Andrews, 1978, *Alloxysta coniferensis* Andrews, 1978, *Alloxysta dicksoni* Andrews, 1978, *Alloxysta filimentosus* Andrews, 1978, *Alloxysta* ... (Hartstedt, 1838), *Alloxysta halli* An- ... (Kieffer, 1909), Al-

A Brand New Species Discovered in Alaska

Three arthropod species never before reported in Alaska have been discovered at Kenai National Wildlife Refuge. A scarab beetle and an alpine bristletail are new to Alaska and a harvestman – better known by the name "daddy long-legs" among laypeople – is new to science.

Dominique Collet, a local entomologist, found the bristletail. While biological technician Matthew Bowser was collecting more bristletails, he found the harvestman. The scarab beetle was collected in a separate activity.

Kenai Supervisory Biologist John Morton is quite excited about the discoveries, which are an important part of the refuge's Long Term Ecological Monitoring Program, in which sweep net samples are taken periodically following a grid that covers the entire 2 million-acre refuge. "In Alaska," he said, "we always start with the big charismatic animals and have to work our way down the chain. Nobody has been looking at insects." The monitoring program will provide a fairly complete picture of the insect fauna of the refuge.

Bowser first worked at Kenai Refuge as a biological technician in 2004. He grew up in Florida, where he became interested in insects even as a youngster. When he ... a young soccer player, he ... looking at the bu... ball. "...

have not been many people here studying them, and there has not been a great agricultural pest problem to push their study forward."

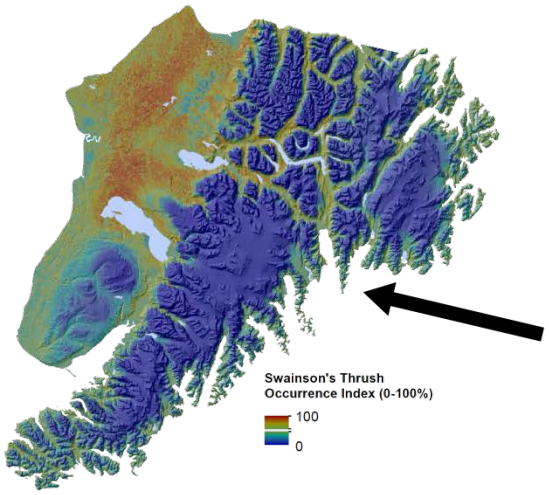
The alpine bristletail looks like a silverfish but has large eyes and an ability to jump. Bristletails live among rocks and feed on algae and lichens. After the first one was discovered, Bowser and a colleague covered headlamps with red cellophane and headed out at night to find dozens of them crawling around on lichen-covered rocks despite a strong wind and a temperature of eight degrees Celsius.

With the help of professional literature and Internet searches, Bowser discovered that the world's foremost expert on bristletails is an elderly scientist in Germany. He is now decidi... bristletail is actu... just ne...

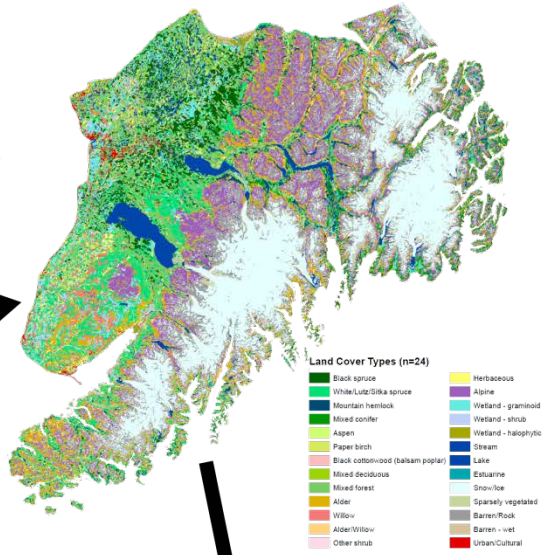
A scarab beetle and an alpine bristletail, new to Alaska, were found ... Kenai National Wildlife Refuge as was a harvestman new to science (USFWS)

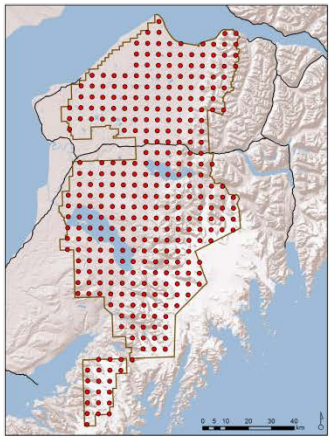
Program, Bowser expects to apply for funding to survey other parts of the Kenai Mountains, the locati... the Skyline Trail whe... s were found. ... "if these are ... e been just ... n is special

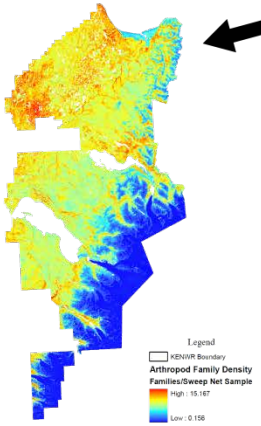
Predictive Models of
Single Species Distributions



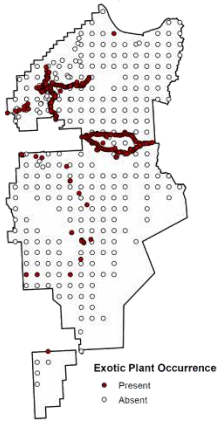
Remote Sensing
Classification



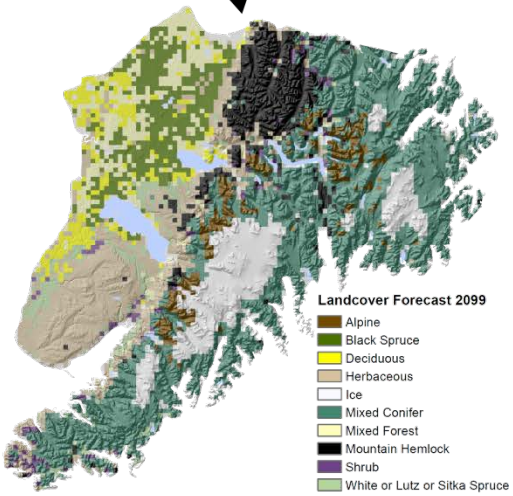




Explanatory Models of
Family Richness



Monitoring for
Adaptive Management

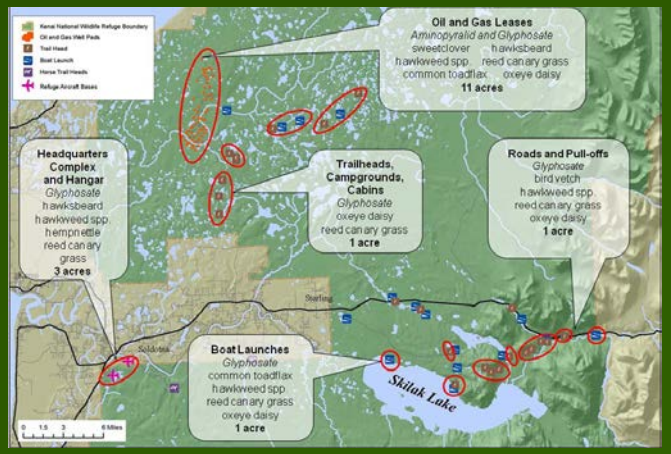


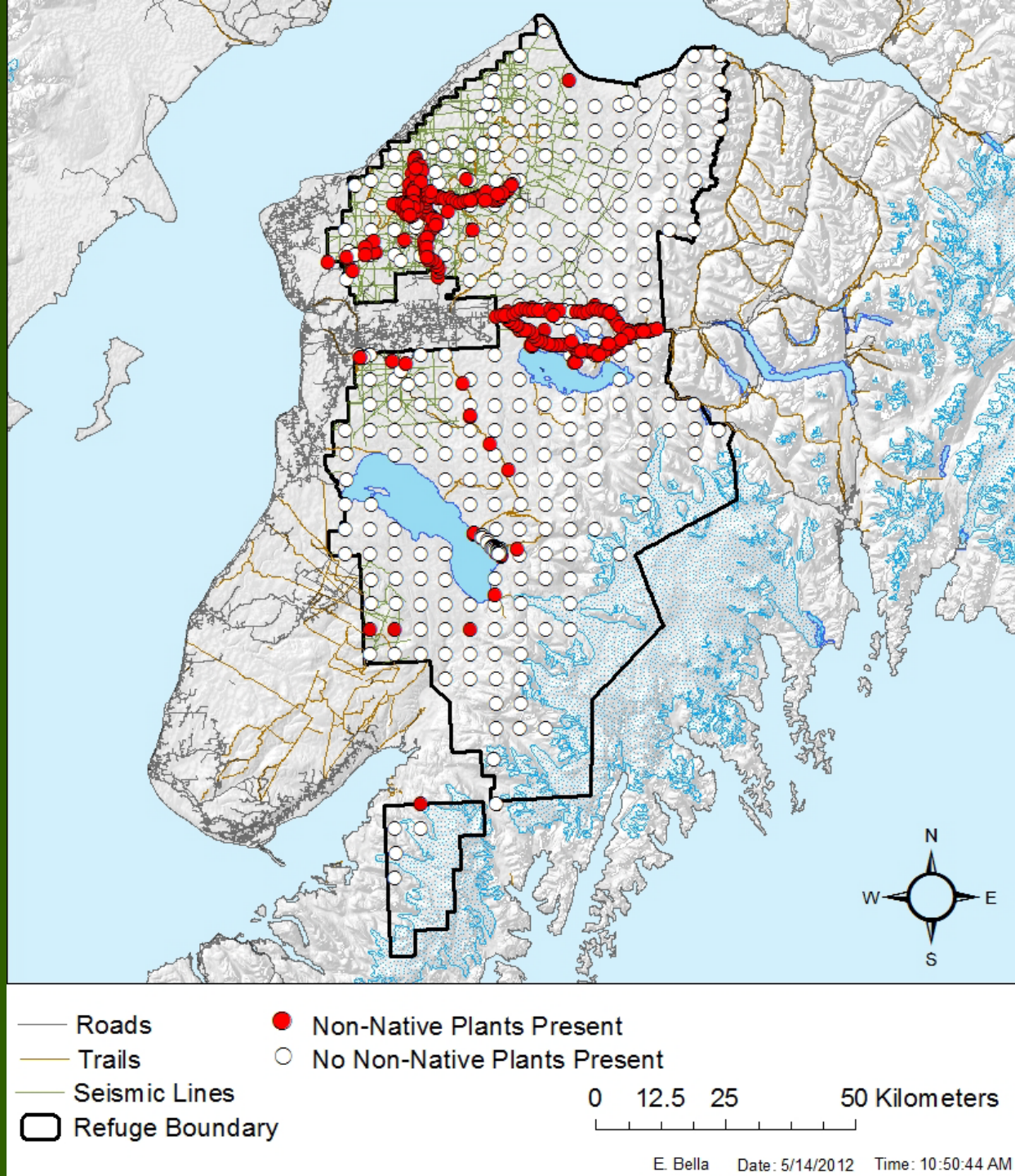
Climate Envelope Models
of Future Conditions

Scaling down…

Invasive plant management

LTEMP 2004 & 06
Slemmons 2005
BAER 2005,06
Hanson Horse Trail 2006
Barnett & Simonson 2007
Swanson Oil Field 2007 & 09



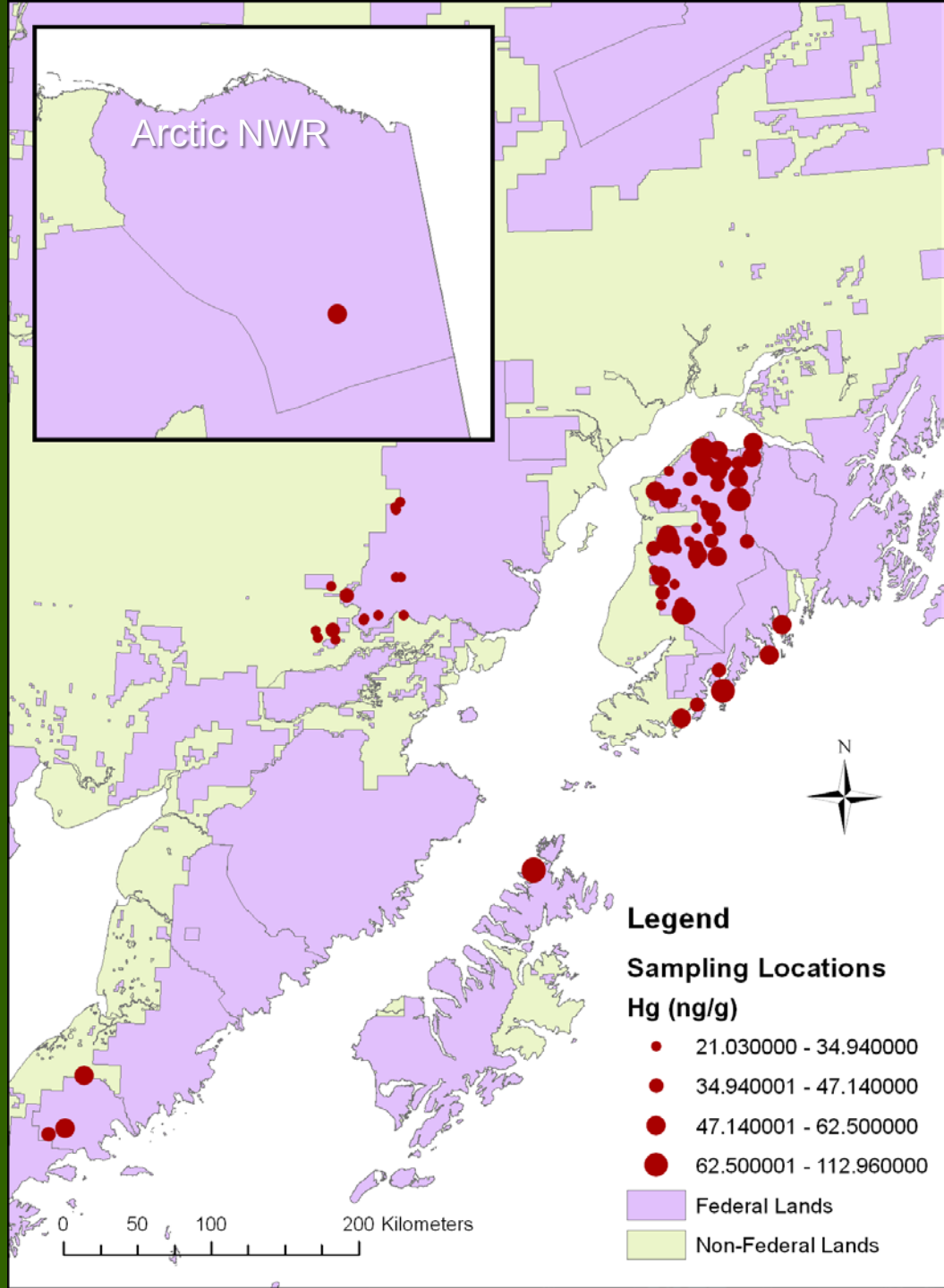


Scaling up…

Heavy metal uptake by *Hylocomium splendens* (Mg, Al, Fe, Mn, Zn, Cu, Pb, Ni, Cr, Cd, sulfur, nitrogen)

Long range air transport:

Asian plume? Anchorage?



What makes LTEMP work?

- Permanent sampling sites to measure change (t_1 of a time series)
- Statistically robust sampling frame (systematic) to survive planned and unplanned habitat changes
- Data are representative of the land (i.e., refuge) unit
- Co-location of biotic & abiotic sampling (modeling)
- All sampling methods are passive, nondestructive (to habitat) and inexpensive
- Multi-taxa sampling and interagency cost-share

Why we have stalled on monitoring…

- Developing methods to measure species-specific detectability using temporal and/or spatial subsampling from a single visit
- Developing reference library for DNA bar-coding

Bulk sampling using second-generation sequencing

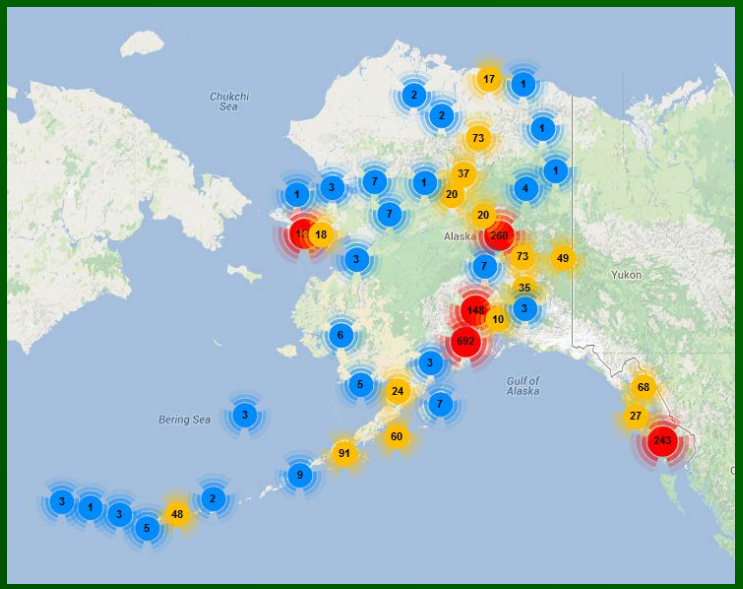
AATAATATATTTTATTTTCGCTATATGATCAGGAATAATTG
GTTCATCTATAAGATTATTAATTCGAATAGAATT
AAGTCATCCTGGAATATGAATTAATAATGATCAGATTTATA
ATTCTTTAGTAACTAGACACGCATTTTTAATAAT
TTTTTTTATAGTTATACCATTTATAATTGGAGGATTTGGAA
ATTATTTAATTCCATTAATATTAGGATCGCCAGA
TATAGCTTTTCCTCGAATAAATAATATTAGATTTTGACTTT
TACCCCCATCATTATTTATACTTCTATTAAGAAA
TATATTTACACCTAATGTAGGAACAGGATGAACTGTATAT
CCTCCTTTATCCTCTTATTTATTTCATTCATCTCC
ATCAATTGATATTGCAATCTTTTCTTTACATATGTCAGGAA
TTTCTTCTATTATTGGATCATTAAATTTTATTGT
TACTATTTTAATAATAAAAAATCTTTCATTAAATTATGACC
AAATTAATTTATTCTCATGATCAGTATGTATTAC
TGTAATTTTATTAATTTTATCTTTACCGGTTTTAGCCGGAG
CTATTACTATATTACTATTCGATCGAAATTTTAA
TACTTCATTCTTTGATCCTATGGGAGGAGGGGATCCAATT
TTATACCAACATTTATTT

Western bumble bee (Bombus occidentalis)

http://arctos.database.museum/guid/KNWR:Ento:2800

Building a regional DNA barcode library

- ✓ >250 arthropod species barcoded (Lepidoptera, Diptera, Hymenoptera, Hemiptera)
- ✓ 95 lichens submitted to CCDB
- ✓ 1,143 sequences in GenBank and BOLD for Kenai Peninsula (marine arthropods, annelids, molluscs)
- ✓ 648 specimens from 2011 Rapid Ecological Assessment being processed
- ✓ 871 of 1,024 arthropod species barcoded at UAM (Derek Sikes)

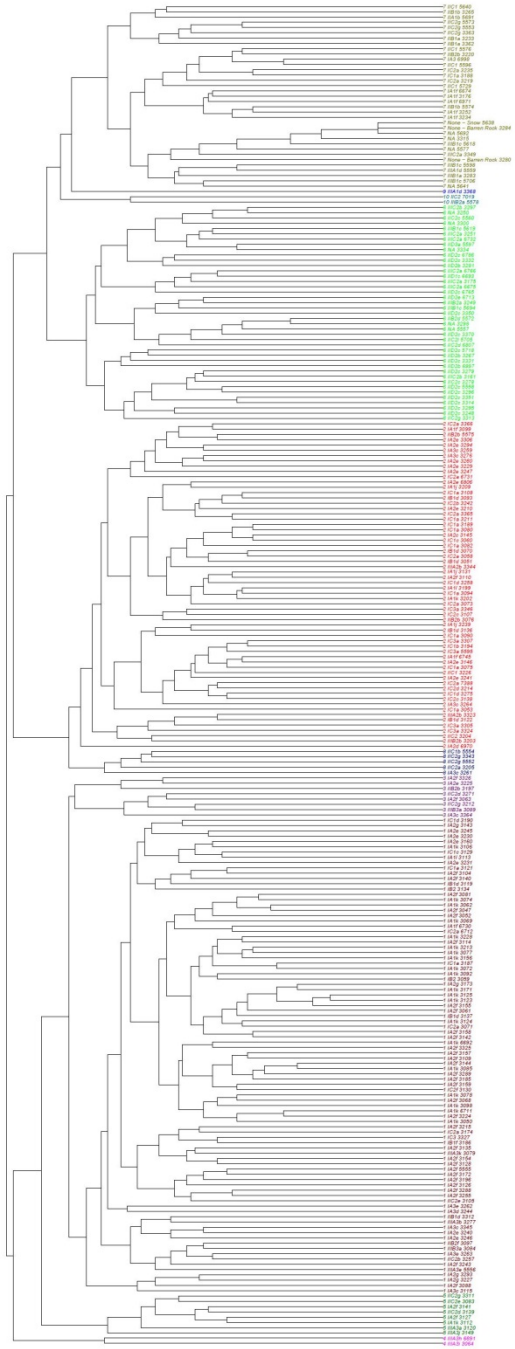


BOLD (http://boldsystems.org)
GenBank (http://www.ncbi.nlm.nih.gov/genbank/)
ARCTOS (http://arctosdb.org/

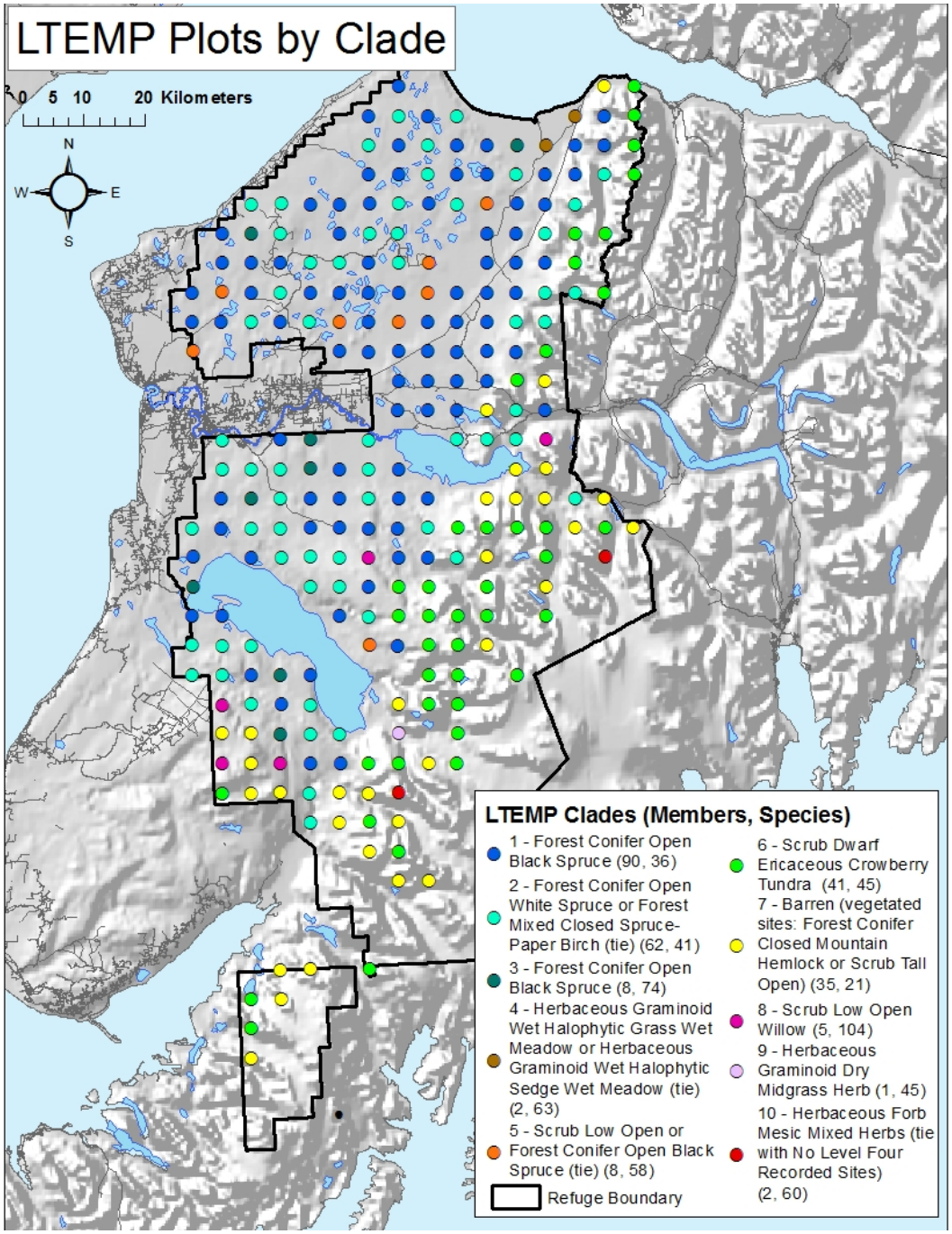
Why we have stalled on monitoring…

- Developing methods to measure species-specific detectability using temporal and/or spatial subsampling from a single visit
- Developing reference library for DNA bar-coding
- Refine monitoring objectives based on quantitative and qualitative concerns
    - e.g., define apriori species assemblages

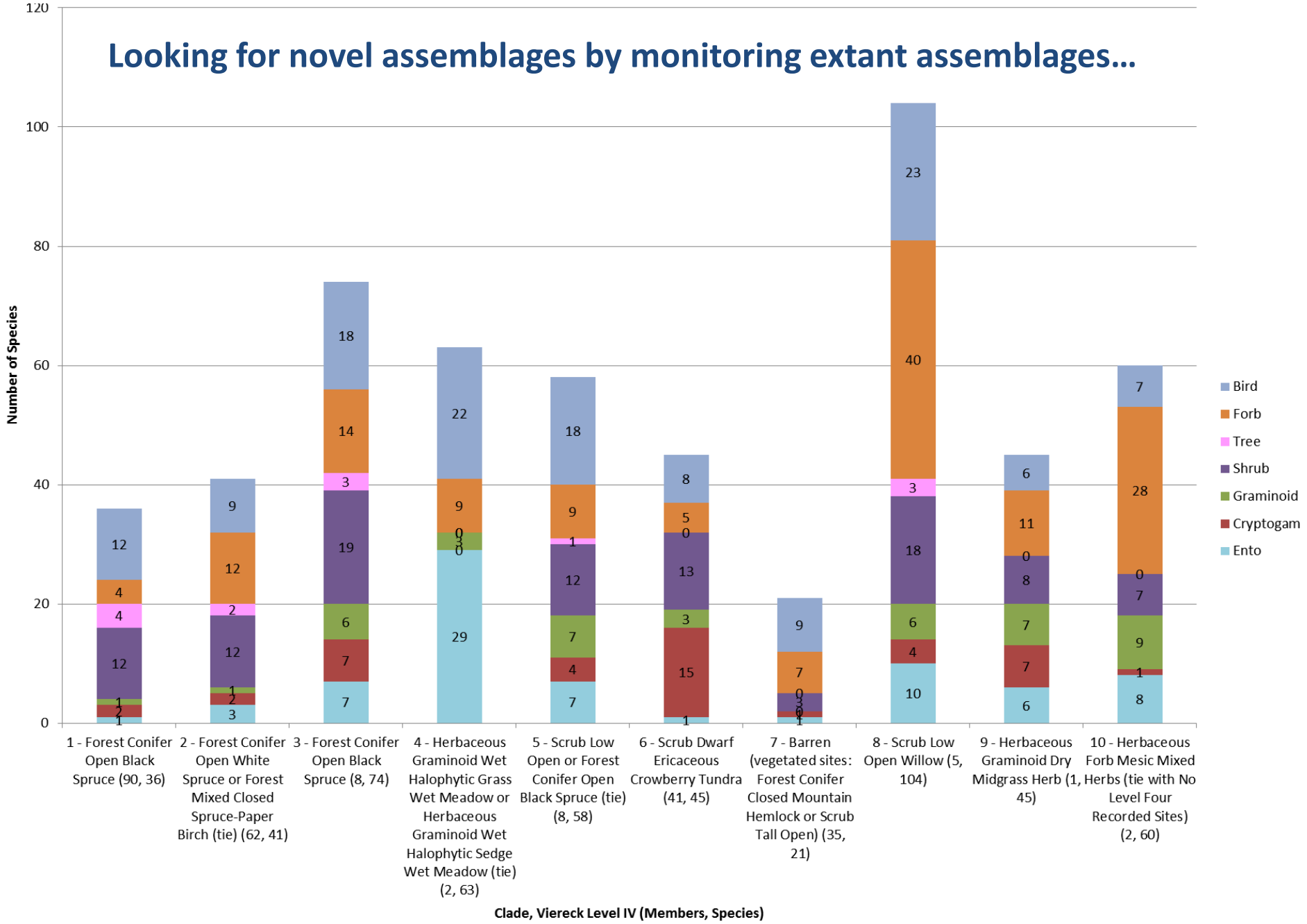
255 LTEMP plots



10 clades (aka species assemblages)



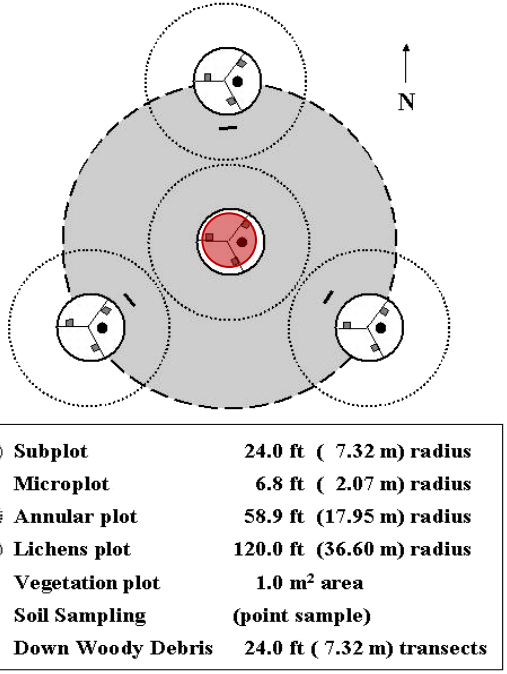
Looking for novel assemblages by monitoring extant assemblages…



What all of this work has in common…

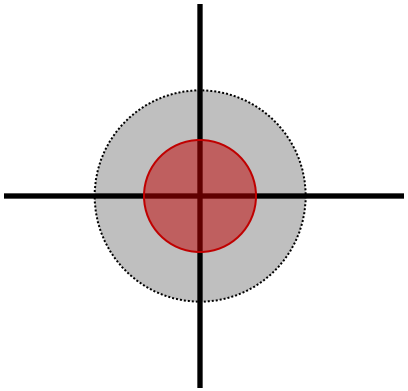
100 m² plot!!

Phase 2/Phase 3 Plot Design



Horizontal-Vertical plot

LTEMP nonforested vegetation



Modified line-intercept

Take home message:

there's more than one way to skin this cat (of collaborating with the FIA)

- ✓ Scaling sideways: Extend sampling to include nonforested plots on FIA sample frame
- ✓ Scaling up: Using data from other agencies or outside management unit but on sample frame (Hylocomium splendens, landcover mapping)
- ✓ Scaling down: Provide landscape context for local scale action (invasive plant management)
- ✓ Leveraging: Adjunct inventory + FIA data = multi-taxa; data are ideal for distribution models now and into the future

Questions????

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Morton, J., M. Bowser, E. Berg, D. Magness & T. Eskelin. 2009. Long Term Ecological Monitoring Program on the Kenai National Wildlife Refuge: An FIA adjunct inventory. *In* McWilliams et al. (eds.). FIA Symposium, Oct 2008, Park City, UT. RMRS-P-56CD. USDA Forest Service, Fort Collins, CO.

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Magness, D.R., F. Huettmann, & J.M. Morton. 2008. Using Random Forests to provide predicted species distribution maps as a metric for ecological inventory & monitoring programs. Pages 209-229 *in* T.G. Smolinski et al. (eds.). Applications of Computational Intelligence in Biology: Current Trends and Open Problems. Studies in Computational Intelligence, Vol. 122, Springer-Verlag Berlin Heidelberg. 428pp.

Bowser, M. 2009. Terrestrial arthropod biodiversity on the Kenai National Wildlife Refuge, Alaska. M.S. thesis. University of Alaska, Fairbanks.

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Sager, K. 2009. Habitat of three forest birds surveyed by the Long Term Ecological Monitoring Program, Kenai National Wildlife Refuge, Alaska. M.S. thesis. Alaska Pacific University, Anchorage.